

“A SENSITIVITY ANALYSIS OF COMBINED EFFECTS MODELING”

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STANFORD TELECOM

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What Does Combined Effects Modeling Do?

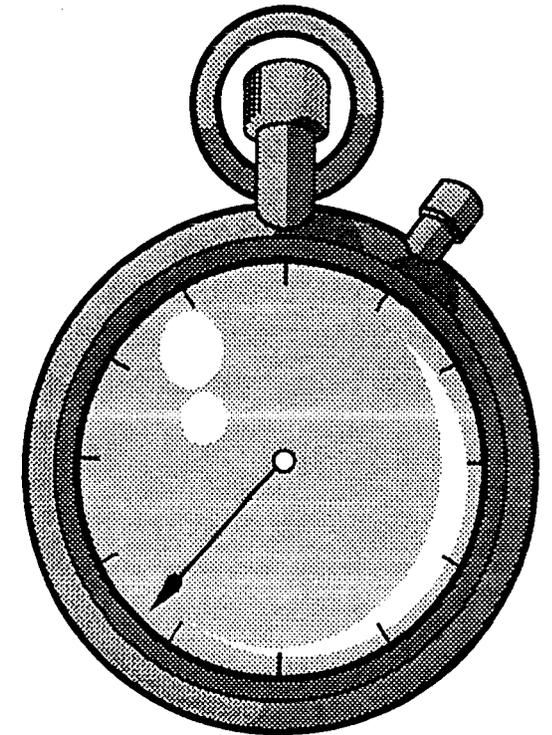
- Models Distributions of Weather Characteristics as Random Variables
- Converts Distributions of Weather to Distributions of Attenuation (dB)
- Assumes Dependence /Independence Between Events
- Creates Upper and Lower Bounds of Joint Probability



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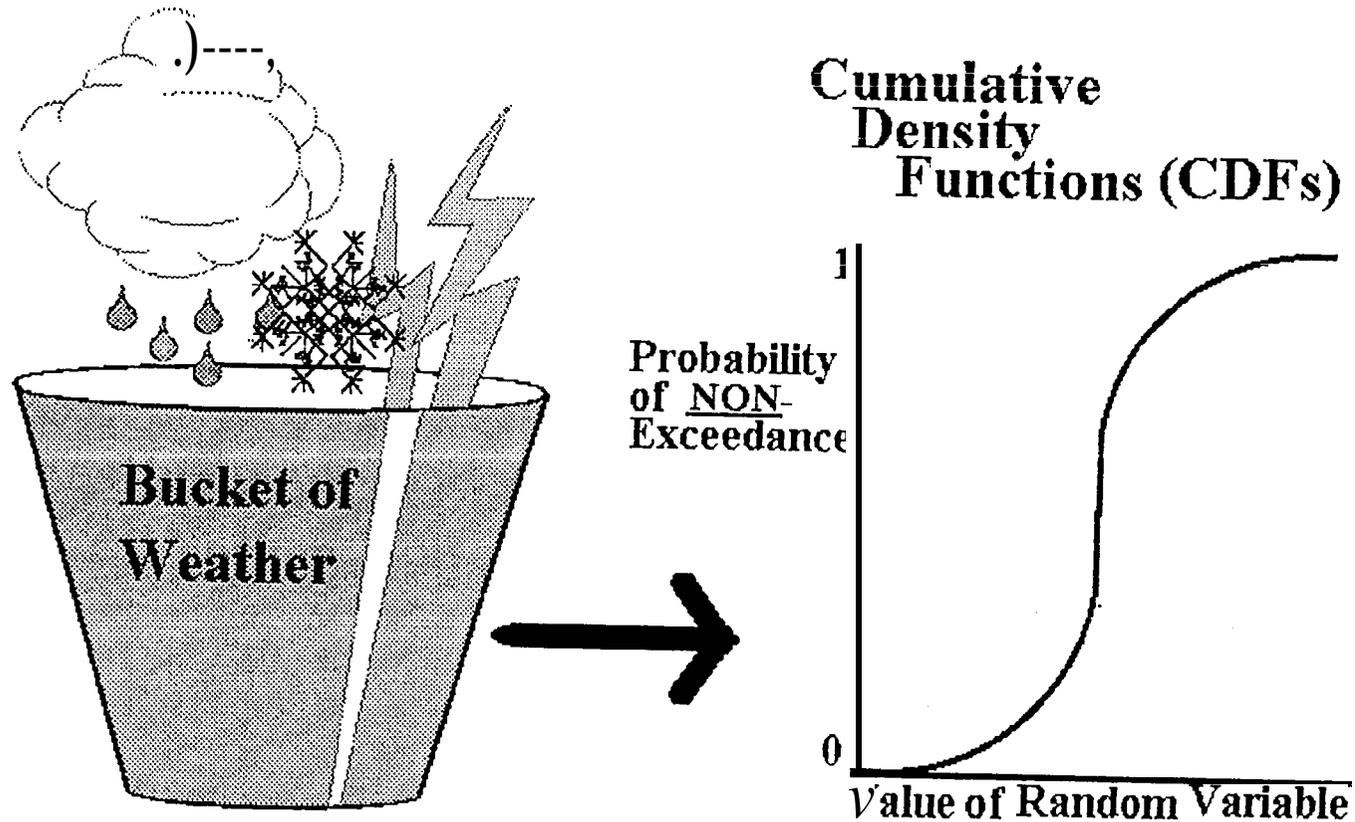
The Five Minute Combined Effects Tutorial...

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WHERE DO WE START?

- ❑ Step 1) Start with a Pool of Weather Data
- ❑ Step 2) Create CDFs of Weather Statistics



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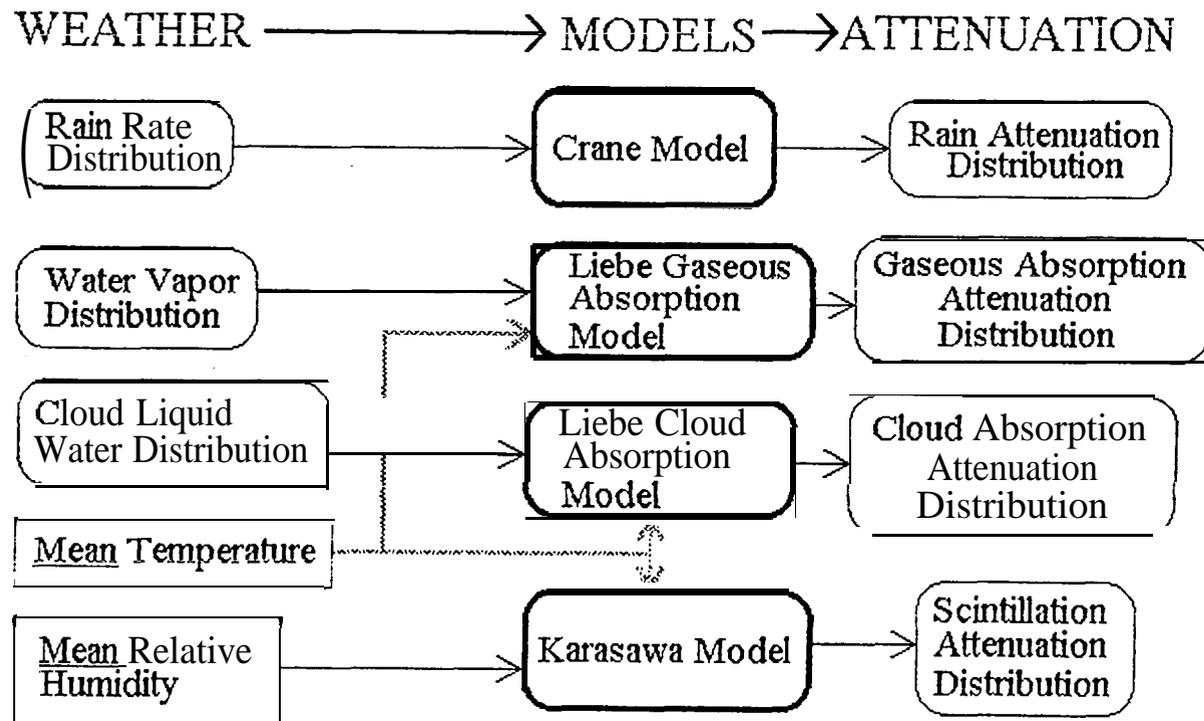
Distributions of Weather Statistics

	JAN	FEB	...	DEC
RAIN RATE STATISTICS			...	
WATER VAPOR STATISTICS			...	
CLOUD LIQUID WATER STATISTICS			...	
SCINTILLATION STATISTICS			...	

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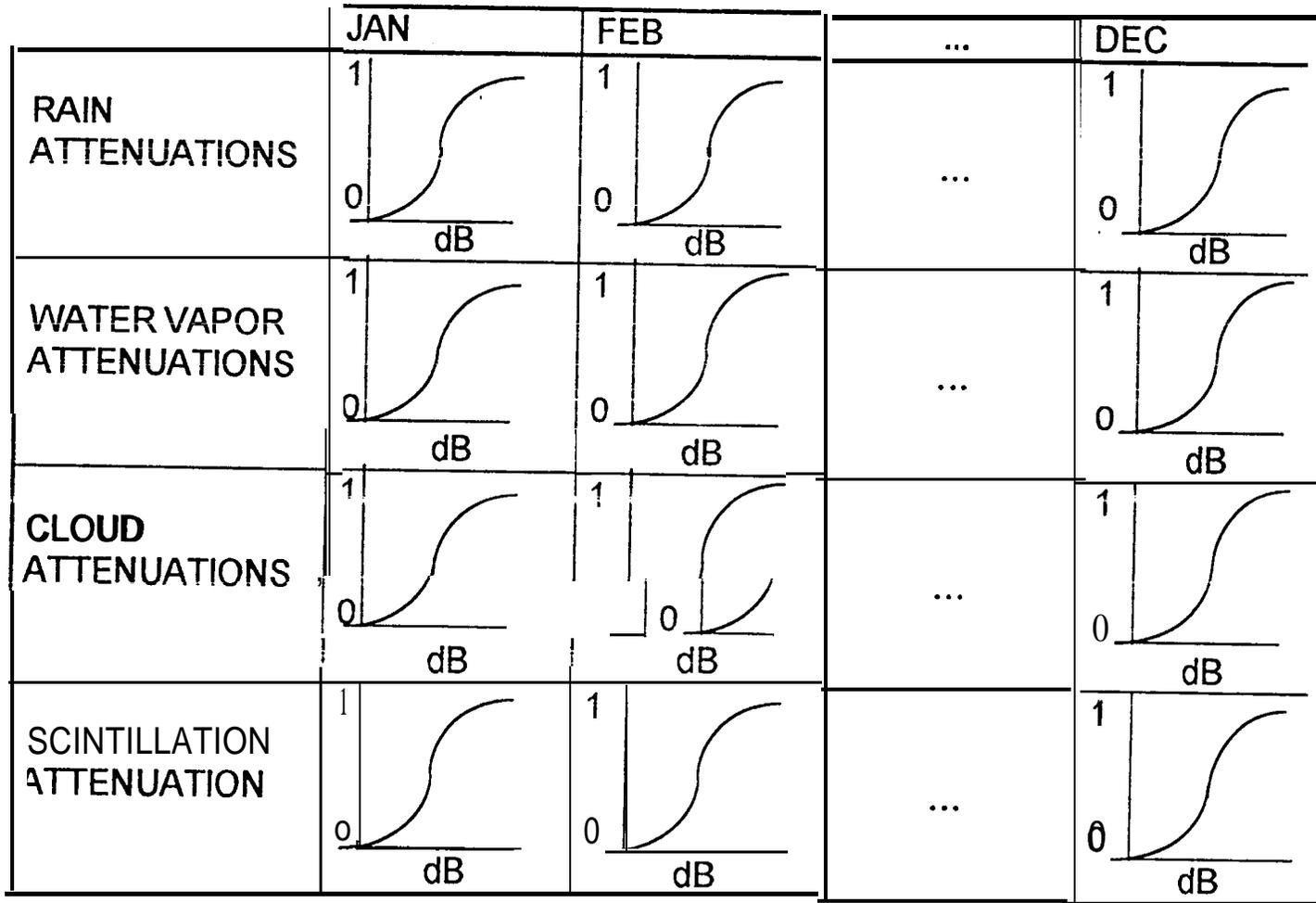
MAPPING WEATHER TO ATTENUATION

- Step 3) Use Distributions of Weather with Models to Create Distributions of Attenuation



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Distributions of Attenuation Statistics



First,
Combine
by Effect

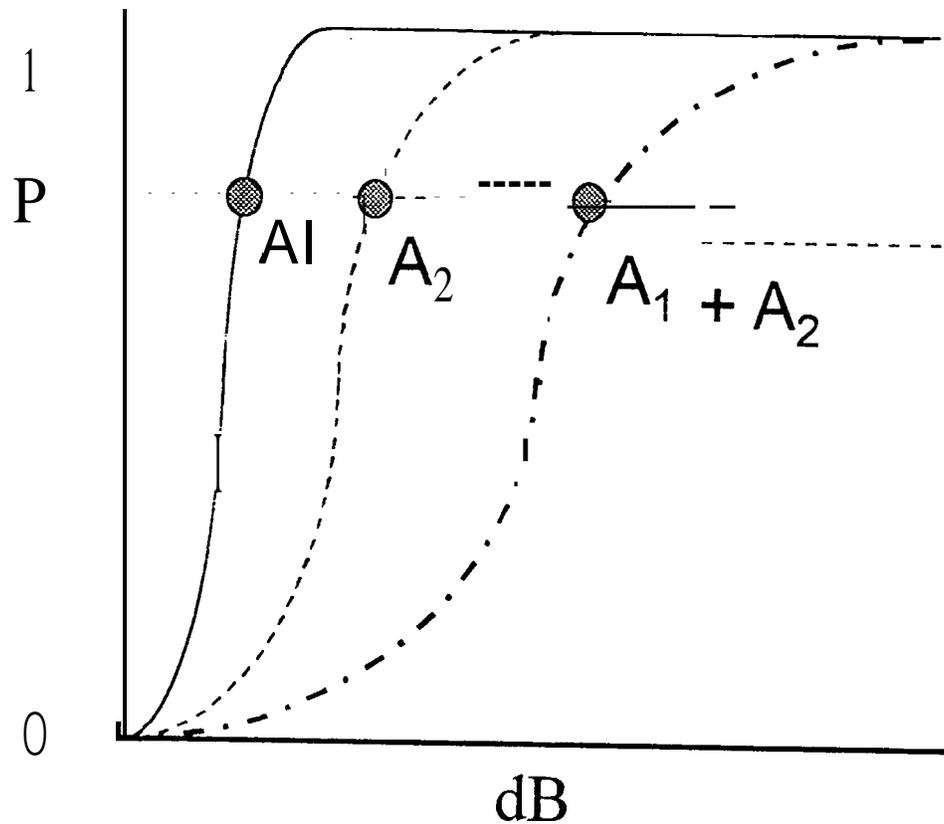
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STEP 4a) COMBINING CDFS DUE TO VARIOUS EFFECTS

- Equiprobable Summation:
 - Effects Are Perfectly Dependent ($r = 1$)
 - At a Fixed Probability, Attenuations are Added Directly
 - Presents a Worst Case Approximation
- Convolution
 - Effects are Perfectly Independent ($r = 0$)
 - The CDF of One Effect Convolved with the PDF of Another Effect Produces the CDF of the Resultant
 - Presents the Most Realistic, Best Case Approximation

Development of a Dependent Curve Through Equiprobable Summation

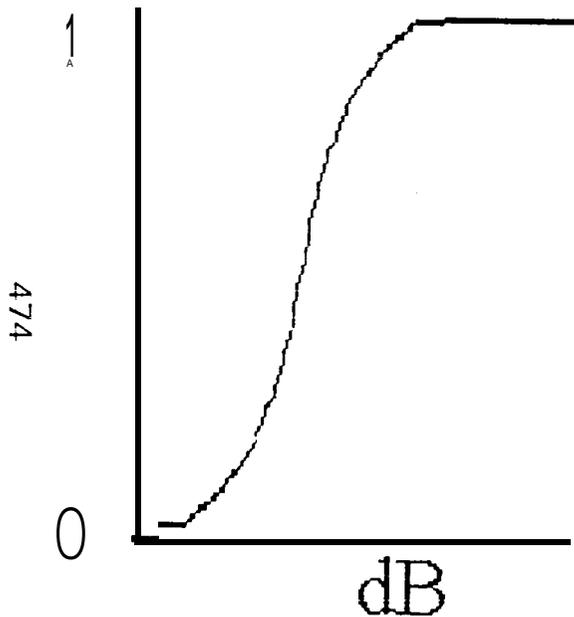
- For a Fixed Probability, Sum the Corresponding Attenuations Due to Each Effect



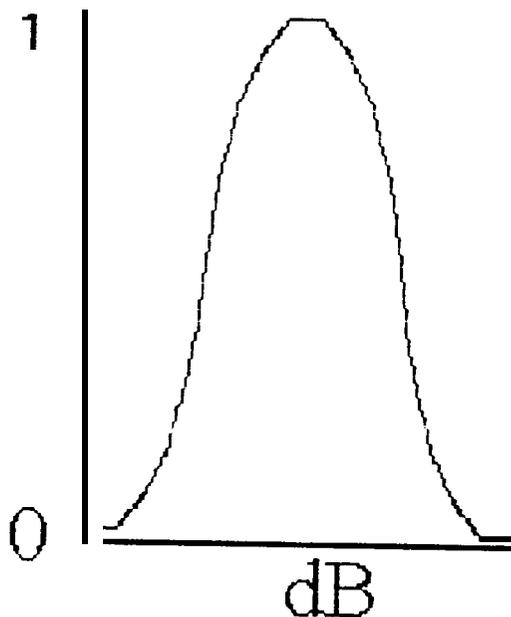
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Development of an Independent Curve

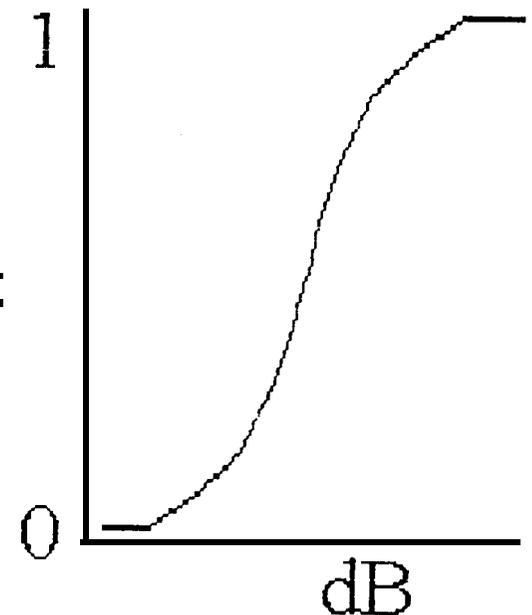
CDF of Atten.
due to Effect #1



PDF of Atten.
due to Effect #2



Independent
Resultant CDF

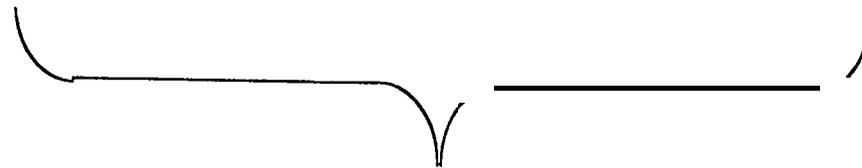
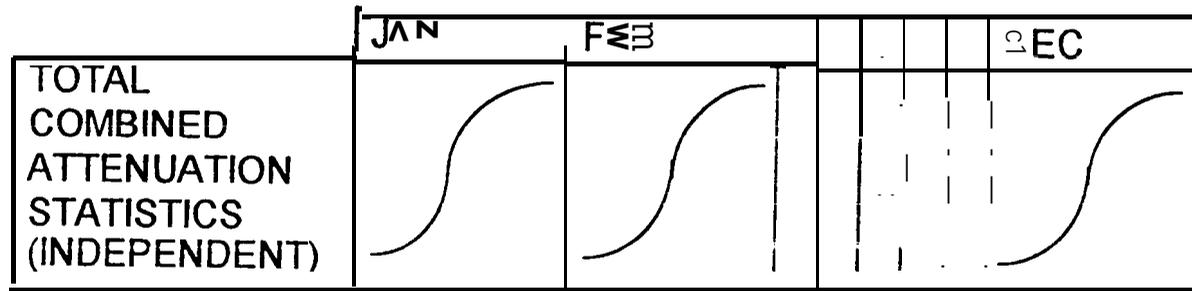
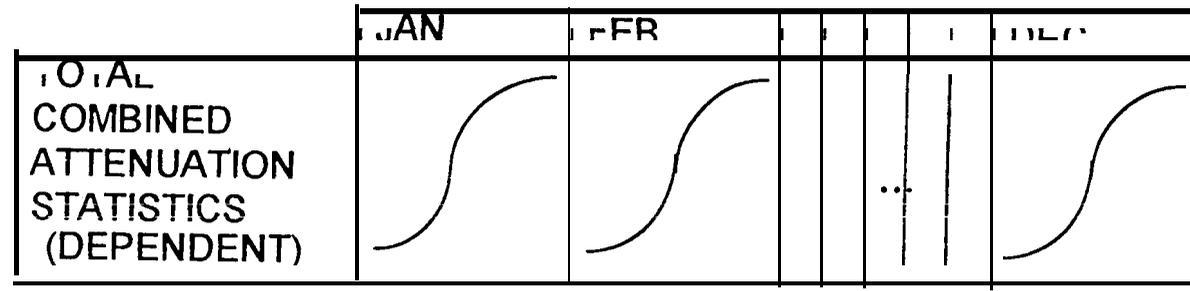


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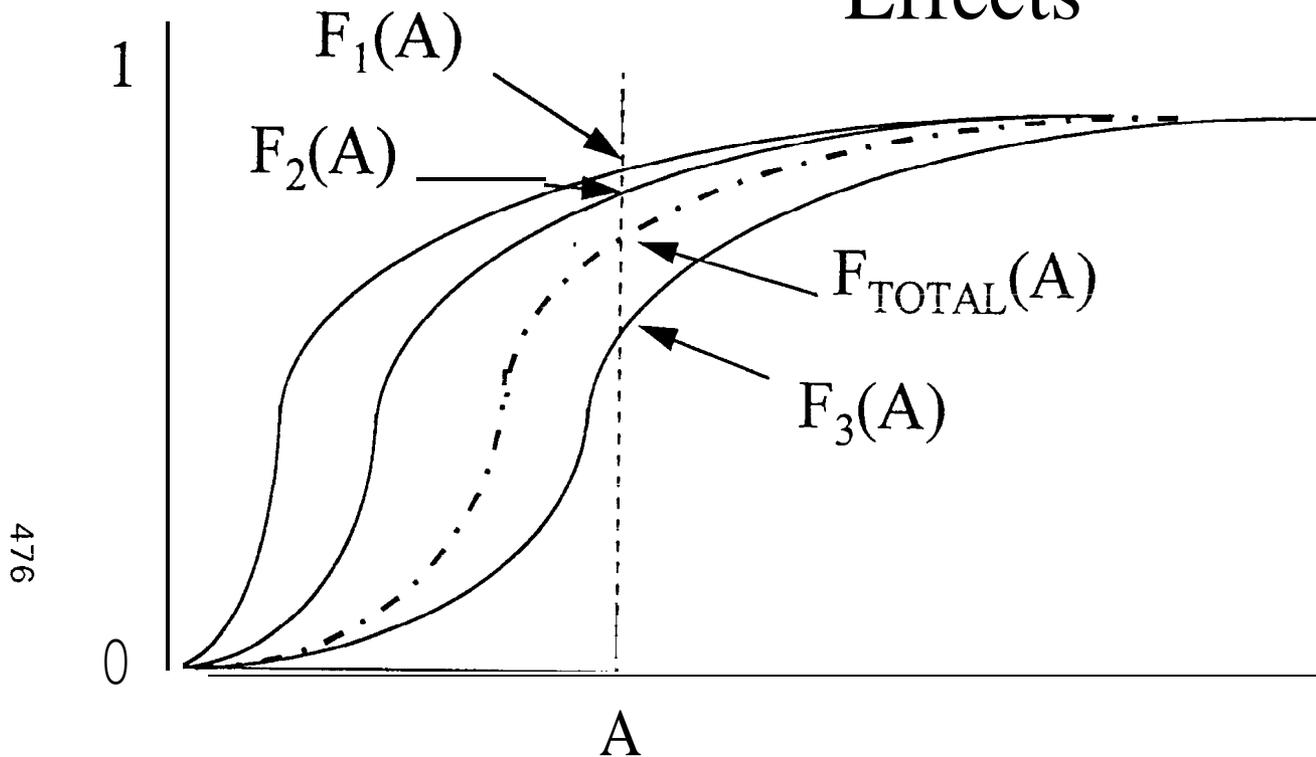
- Where * Represents Convolution
- All Points on the CDF are Required

STEP 4b) COMBINING CDFs FOR DIFFERENT TIMES



Next, Combine by Time Using Bayes Theorem

Applying Bayes Theorem to Combined Effects

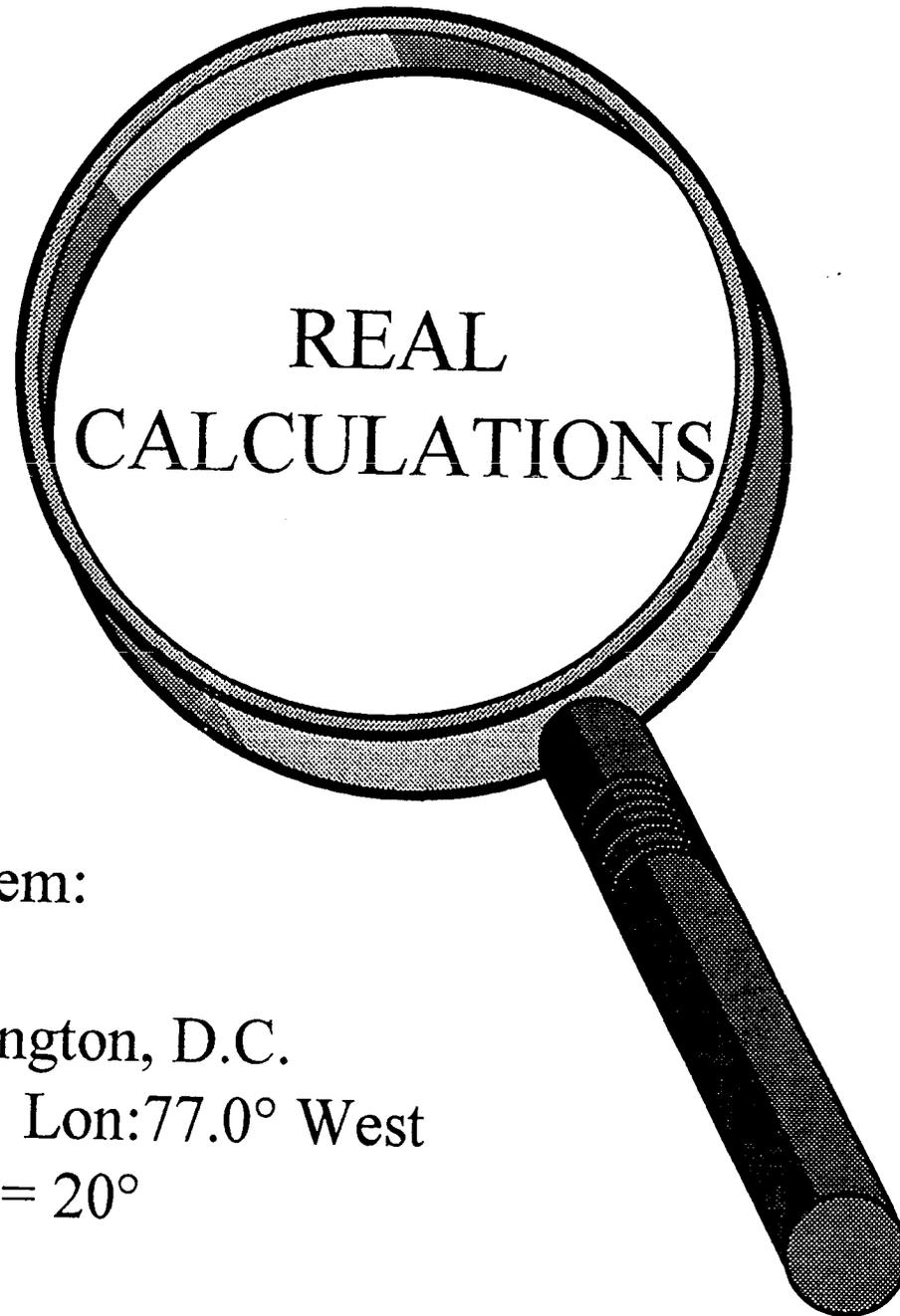


Assume Each CDF Represents 1 Month

- Month1: 30 Days
- Month2: **31** Days
- Month3: 30 Days

$$F_{TOTAL}(A) = \frac{F_1(A) * n_1 + F_2(A) * n_2 + \dots + F_N(A) * n_N}{\sum n_1 + n_2 + \dots + n_N}$$

$$= [F_1(A) * 30 + F_2(A) * 31 + F_3(A) * 30] / 91$$



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Theoretical System:

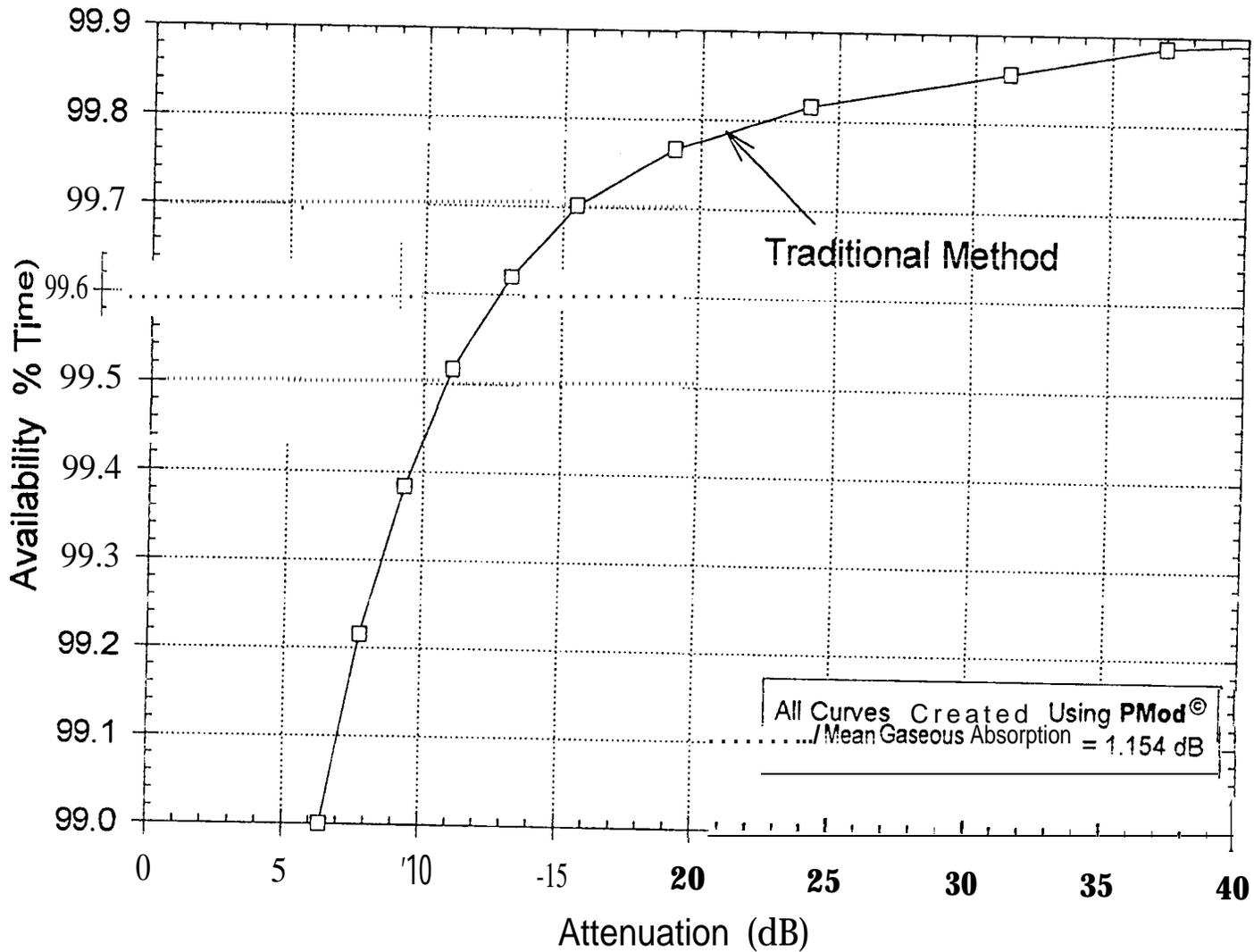
$f=27.505$ GHz

Location: Washington, D.C.

Lat: 38.4° North Lon: 77.0° West

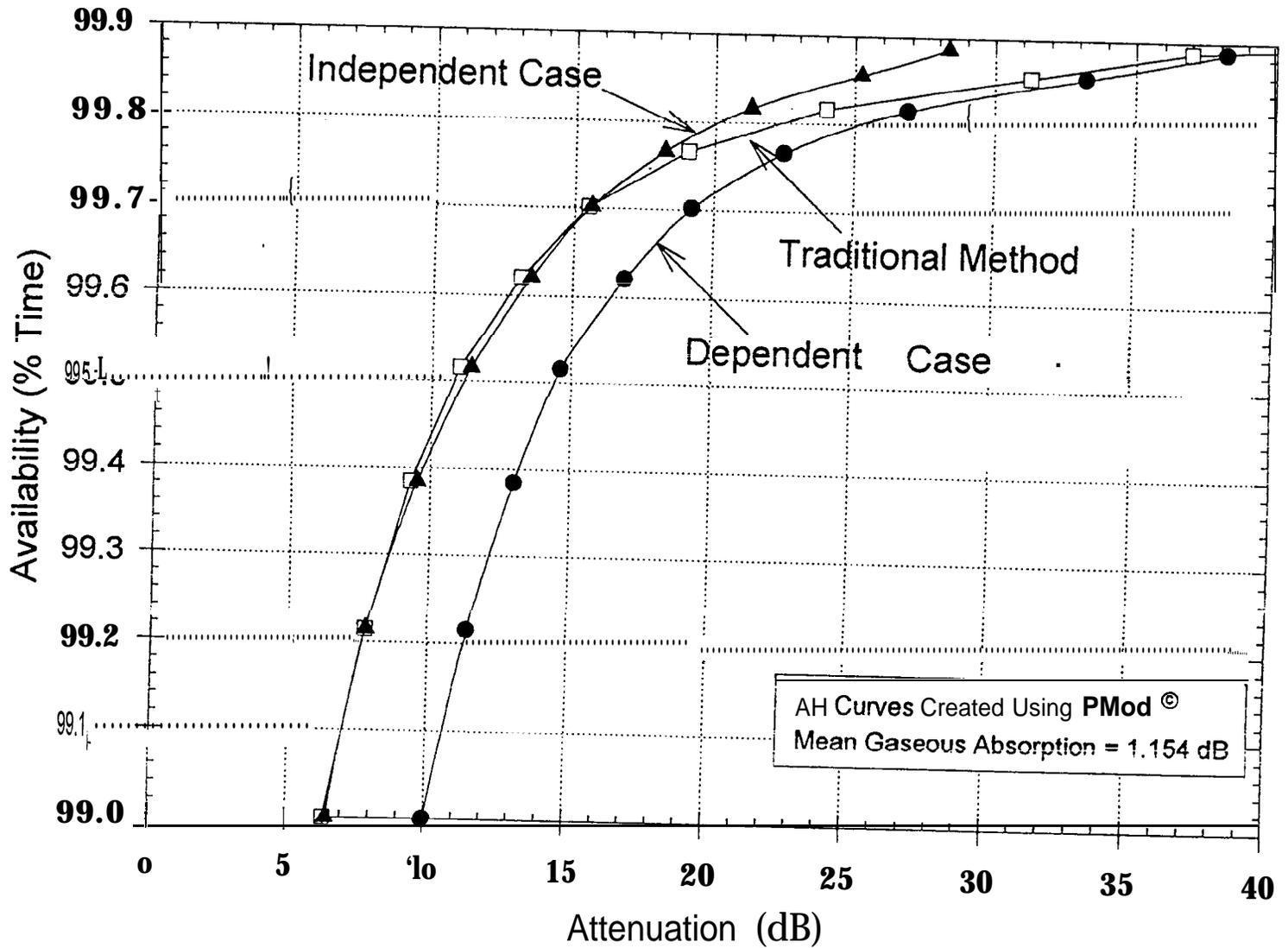
Elevation Angle = 20°

Traditional Approach to Attenuation Approximation (Rain CDF + Mean Gaseous Absorption)



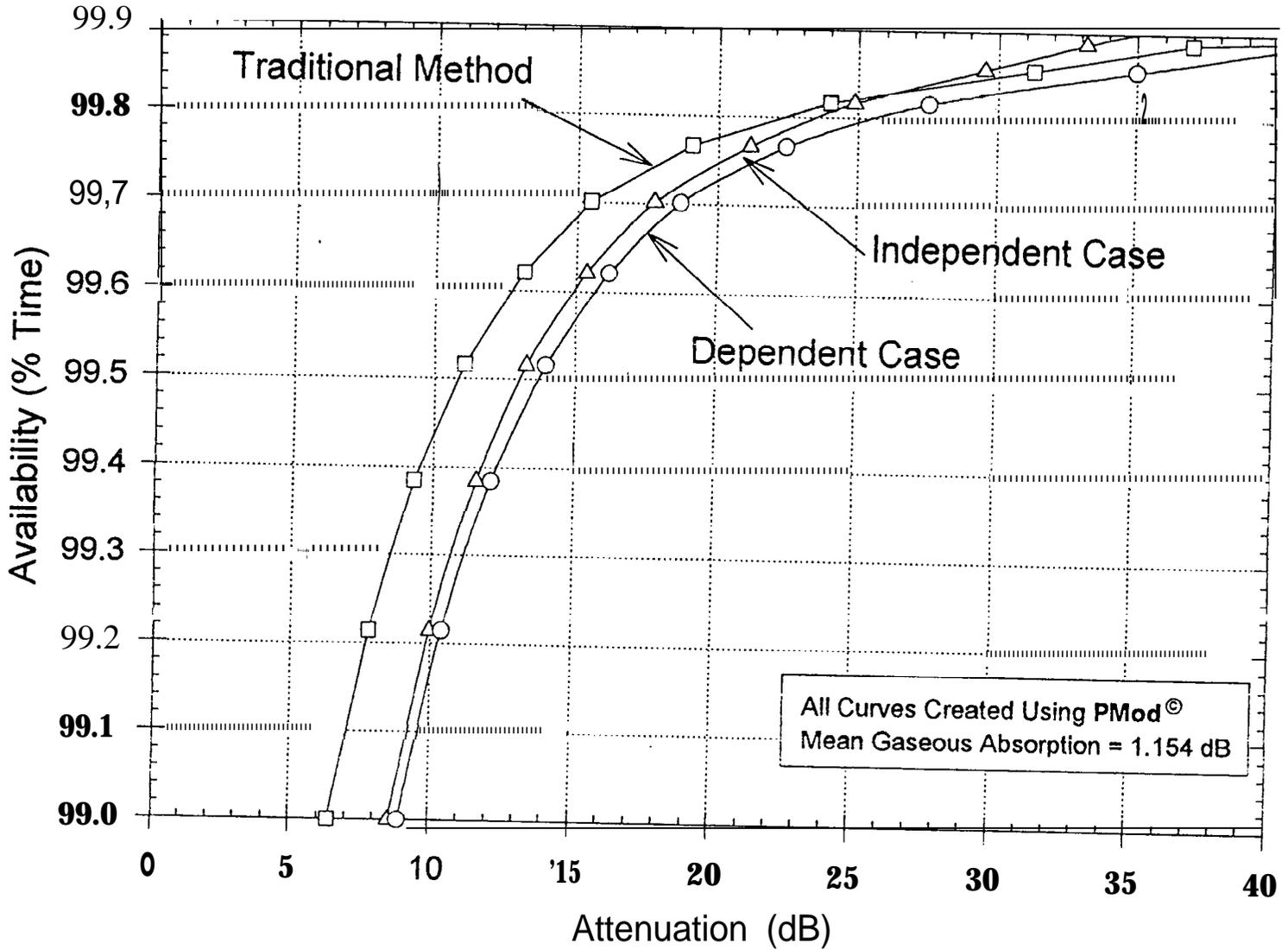
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Traditional Approach v Annual Combined Effects



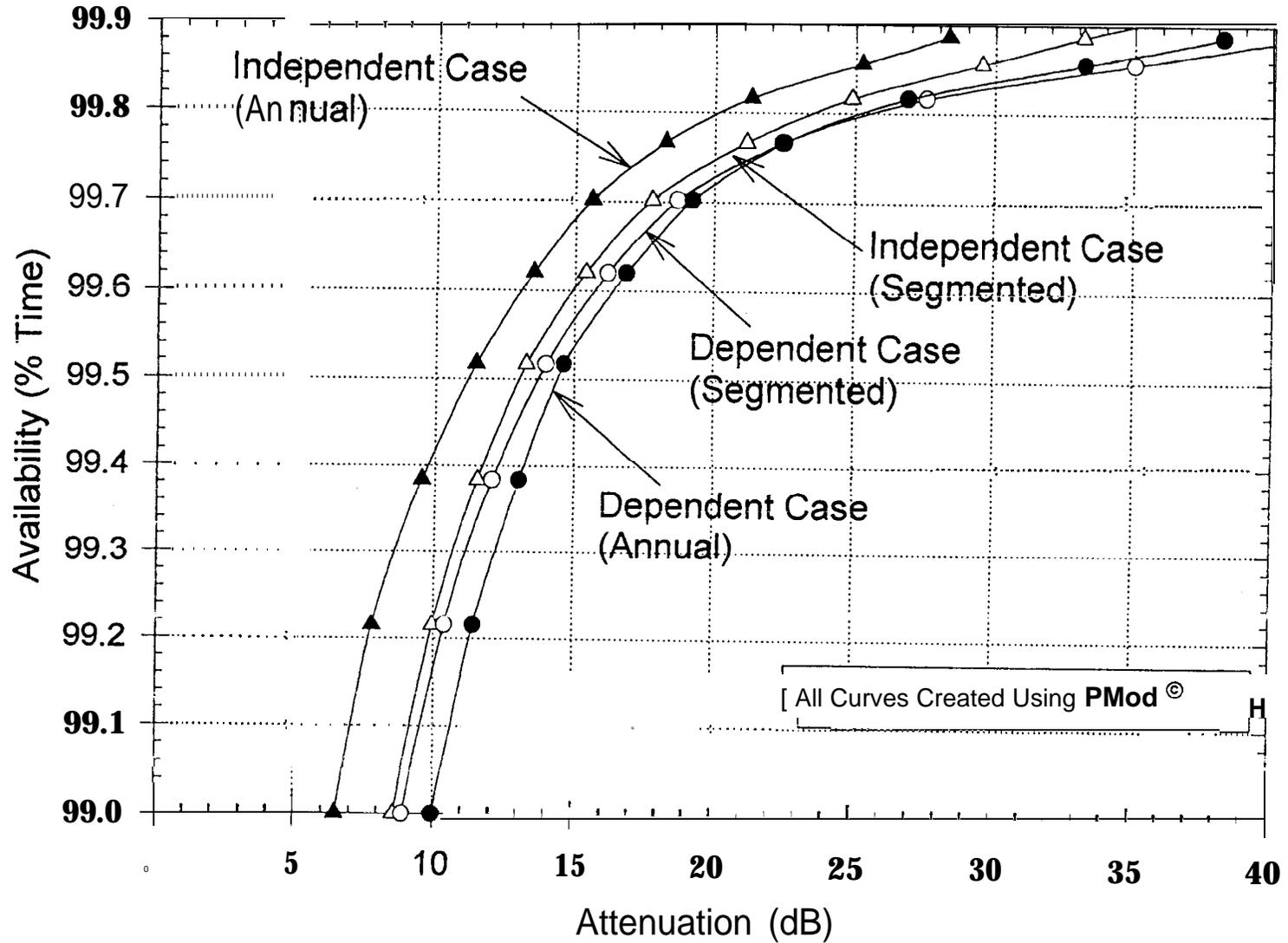
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Traditional Approach v Segmented Combined Effects



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Annual v Segmented Combined Effects



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